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Measuring the Trade-Off Between Economic Growth and a Clean Environment

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Abstract. This article surveys various aspects of the measurement of environmental quality from the view point of national accounting and welfare economics. It focuses on the question whether GNP or NNP should be corrected for environmental change ('green' or 'eco'-GNP) or whether physical accounts provide sufficient information for an assessment of the trade-off mentioned above. We conclude that valuation of (services from) environmental capital cannot be avoided for such assessment, but can only be made using a model based approach. Statistical agencies should continue to collect data on environmental quality and to value changes in environmental capital in the context of national resource accounting. However, official statisticians should refrain from correcting GNP or NNP for environmental change, as this correction implicitly contains a political judgement and cannot be based on mere technical knowledge.

Key words. Green GNP, optimal economic growth, sustainable development, environmental capital, environmental valuation, indicators.

1. Introduction

A proper measurement of the state of the environment is a major issue in the debate on the economic relation between growth and the environment. This measurement problem is closely linked to the question on the trade-off between economic growth and environmental protection. If it is conceived that from a long term perspective economic growth and environmental protection are being reconciled in the concept of sustainable development, this trade-off is especially a short term, but nevertheless highly sensitive dilemma. Two extreme and opposite lines of thought in this respect are:

1. economic growth is essential for abatement of environmental damage, and;
2. economic growth inevitably causes environmental damage so that economic decline (negative economic growth) is essential for a cleaner environment.

According to the second proposition clearly a negative trade-off exists between economic growth and the state of the environment. However, the trade-off may also be negative under the first proposition when economic growth is needed to finance abatement costs and measures to protect the

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environment. For, if such costs were not incurred economic growth, in the traditional sense, could be even higher.

Two alternative methods are proposed for the statistical registration of the trade-off between economic growth and the state of the environment. The first method is to correct, in one way or another, GNP for environmental change and arrive at a so-called environmentally adjusted GNP: 'green' GNP or eco-GNP. The other method is to calculate one or more physical indicators for the state of, or the pressure on, the environment and to relate these indicators to GNP growth. Both methods obviously represent opponent strategies, which stem from different schools of economic thought. A correction of GNP implies a monetising of environmental degradation (or upgrading) by the statistical agency that publishes these data. It affects the definition of national income and requires an amendment of the theory of national accounting. On the other hand, the calculation of physical indicators leaves the final valuation of the trade-off between economic growth and a clean environment to the users of the data. Then, it may become a political rather than an economic valuation. However, both strategies are not opponent in every respect. For the construction of composite indicators of the state of the environment some valuation cannot be avoided as various aspects of pollution are to be added, whereas calculation of a green GNP implicitly defines an overall indicator for the state of the environment, namely the difference between the traditional GNP and the corrected figure for GNP. Most proponents of a green GNP will not advocate publishing the corrected data for GNP *instead* of the traditional GNP, but will advocate publishing both data series, so that such implicitly defined indicator can always be computed from the published data.

This article discusses the pro's and con's of these alternative strategies and reviews the arguments within the context of the theory of national accounting. The United Nations give resource and environmental accounting an important place in their new guidelines for the system of national accounts (SNA). Against this background special attention is paid to a method for the correction of GNP for environmental damage in the national account proposed by Hueting (see Hueting *et al.*, 1992).

The next section surveys the literature on the definition of national income, on environmental indicators and on the role of the environment in theories of economic growth. Section 3 discusses the valuation problem of the environment form the point of view of welfare theory. Section 4 assesses Hueting's method both within the framework of national accounting and of economic modelling. Finally, Section 5 evaluates this method and provides suggestions on how to proceed with the collection of statistical data and their valuation needed for a model based assessment of the trade-off between economic growth and a clean environment.

2. Survey of the Literature

The definition of national income is a prominent issue of the theory of national accounting. The origins of the present national accounting systems can be traced back to the first national income estimates by Petty and King in 1665 and 1696, respectively (see Bos, 1992). Petty and King employed a comprehensive and broad concept of production and income, according to which production of goods as well as services generate value added. Such a broad concept is also used in the UN guidelines for the system of national accounts (SNA) of 1968. However, this concept has not always been beyond dispute. We recall that the Physiocrats argued that only agriculture could generate value added and that the other sectors were 'sterile'. Adam Smith himself, and many of his classic followers, regarded the whole civil and military personnel of the government, the professions, the domestics and other engaged in the performance of personal services and the services of dwellings as unproductive labourers. Pigou (1932) pointed to yet another anomaly, namely that the money measure of national income, as part of total welfare, does not comprise unpriced externalities, both negative and positive. According to Pigou, this causes divergences between private and social income, which in the case of diseconomics should be internalized in the market forces by a tax on the activity causing the negative externality. He also drew attention to changes in the distribution of income that are neither revealed by the money measure of national income. Only from the 1930s onwards the present broad concept of national income gained general acceptance, although its shortcoming as indicator of (economic) welfare remained subject of discussion. In those days Clark and Kuznets contributed pioneering efforts to the theory and practice of national accounting. Kuznets (1948) conducted a famous discussion in *Economica* with Hicks (1940, 1948) on the valuation of the heterogeneous collection of economic goods and services to be included in National Income, which was explicitly regarded as an index of economic welfare. Clark advocated the inclusion of the services of owner occupied dwellings and the exclusion of services of consumer durables and the exclusion of holding gains and losses from national income. Moreover, he already indicated a possible 'deduction for any demonstrable exhaustion of natural resources' (Clark, 1937, p. 9).

However, up to now Clark's idea of correcting national income for depletion of natural resources has not yet gained wide acceptance by producers of national account statistics. There are only a few examples of in this way corrected GNPs. A study by Repetto *et al.* (1989) on Indonesia aimed primarily at corrections of GDP for quantitative and qualitative changes of natural resource stocks. Stocks and flows of crude oil, timber and the exploitation of soils for crop production were valued in monetary terms. Over the period 1971 to 1984, the average annual GDP growth rate was adjusted downwards from 7.1 to 4.0 per cent. More in general, Repetto

(1990) proposes to extend the registration of capital and capital depreciation in national accounts to natural resources capable of yielding a positive net income under current market and technological conditions. In this (narrow economic) approach *Net* National Product and *Net* National Income are corrected to take into account the depletion and degradation of natural resources in a manner consistent with depreciation charges for other forms of physical capital.

A second empirical example is a joint effort of the World Resources Institute and Costa Rica's Tropical Sciences Centre (1991). They estimated Costa Rica's economic loss of natural resources (forest, soils and fisheries) to be worth more than one year's GDP between 1970 and 1989. If these three resources would have been depreciated and recorded properly, this would equal a 5 per cent of GDP loss each year. A further comprehensive attempt of assessing the value of exploitable natural resources and the conditions for their regeneration is made in Norway (Arntzen and Gilbert, 1991). Due to, *inter alia*, lack of data, the Norwegians have not come up with adjusted GDP figures. The other attempts to value the loss of environmental capital assets have remained partial so far.

Another major environmental shortcoming of the SNA of 1968 is the inconsistent way in which pollution control and other types of environmental rehabilitation expenditures are dealt with. If incurred by the government and households, these so-called defensive expenditures normally result in an increase in GDP, but are, of course, incurred to undo an unreported negative externality: a case of double-counting. As similar pollution control expenditures are done at the source by firms, they are considered an intermediate input and hence do not inflate GDP, apart from the capital and labour used in this input. The proposed adjustment is to treat defensive expenditure as intermediate and should thus be deduced from GDP. Worth mentioning is Leipert's attempt to measure the defensive expenditures (in a broad sense) in West-Germany from 1970 to 1988. He found that during that period the share of defensive expenditures in GDP rose from 7 to 11.6 per cent (Leipert, 1989).

As indicated above, correcting GDP for resource depletion and "double-counting" should ideally be related to Net instead of Gross Product, the difference being on allowance for depreciation of man-made capital. We then arrive at Daly's (1989) 'sustainable social net national product,' which equals Net National Product less depreciation of natural capital and defensive expenditures.

GNP (or NNP) corrections for environmental change are not beyond dispute because of a number of conceptual problems which we will consider in more detail in the next sections. There are two main arguments against such correction, which should be mentioned beforehand. The first is that in the present national accounting framework national income relates to actual income whereas a correction for environmental damage is connected with hypothetical income (see Opschoor, 1991). The second major argument relates to the problem of valuing and even monetising of environmental change.

In spite of these conceptual problems, the Statistical Office of the United Nations (UNSO) published a preliminary draft of a system of integrated environmental and economic accounting (SEEA) in which it suggests to impute monetary values on the depletion and degradation of natural resources and environmental goods, and the introduction of the concept of eco-domestic product (EDP) (UNSO, 1990). Thus, in this document (which evoked much criticism) the United Nations indeed advocate the construction of an environmentally adjusted measure of national income. The valuation procedure suggested by UNSO is to estimate 'the costs which would have been necessary to keep the natural capital intact' (see also Nyborg, 1991). As we will see in Section 4 this document of the United Nations is in line with Hueting's proposal for a correction of national income for sustainable use of the environment.

Yet the main UNSO proposal for SEEA is a system based on the framework for resource accounts in physical units. Such physical accounts would seem useful tools for including environmental assets in calculations of wealth (see Nicolaisen, Dean and Hoeller, 1991). These physical accounts can, in a so-called 'satellite account', be connected with the traditional system of national accounts. Satellite accounts can be defined as data sets of particular subjects which supplement the central economic data as described by the system of national accounts. Their purpose is to enable more detailed analyses than is possible with the information contained in the SNA or analyses using different definitons, while maintaining an explicit link with the traditonal overall system. In the Netherlands, the theoretical design for an environmental module to the SNA, which yields such satellite account, is made by De Boo *et al.* (1991). The aim of this module within the general framework of the SNA is to provide a systematic and complete account of the effects of economic activities on the environment and vice versa. In the environmental module a clear connection between data on investments, production and consumption, and data on all kinds of changes in the environment is made. As changes in the environment can take many different forms, such as the depletion of resources, changes in the use of space or the pollution of the environmental media (water, soil and air), different aspects of environmental damage are distinguished in the environmental module and physical data for it are given in separate cells of the accounting matrix. Unlike the calculation of a green GNP, part of the valuation problem is left to the user of these accounts.

Accordingly, indicators for the state of the environment can be derived from these physical accounts of the environmental module. Yet, the construction of environmental indicators should not necessarily be confined to the framework of national accounting. In a broader sense, much effort has been put into the construction of indicators of sustainable development which summarize various aspects of environmental change in a comprehensive and quantitative manner.

In this connection, three types of indicators have been proposed (Opschoor and Reijnders, 1991; Gilbert and Feenstra, 1992; Verbruggen and Kuik, 1991):

1. pressure indicators;
2. impact indicators; and
3. sustainability indicators.

Pressure indicators show the development over time of amounts or levels of emissions, discharges, depositions, extractions, and interventions originating from (a set of) economic activities, either regionally or sectorally defined. These indicators express the burden placed on the environment by man's activities. *Impact indicators* reflect the impact of this burden, and in the case of transboundary externalities also the imported burden, on the receptors, usually in a predetermined region. They show the development over time of environmental quality levels. As human beings are direct and indirect receptors, impact indicators could comprise health indicators. Preferably they should also indicate repercussions on the pattern of welfare over time (Opschoor and Reijnders, 1991). Both pressure and impact indicators can be transformed into *sustainability indicators* by relating pressure and/or impact with predetermined reference values. These references might be criteria for sustainable use, a past environmental state or a desirable future state. Sustainability indicators are normative in nature for two reasons. First, they picture a distance between current and reference values that should be bridged. Second, although the reference values are based on scientific insights, they are inevitable the outcome of political negotiations and hence reflect a social preference for environmental quality.

Preferably, indicators should provide adequate information on the system as a whole. This points to the need of aggregation which is inherently complicated when dealing with physical data in different units. Sustainability indicators can more easily be aggregated than pressure and impact indicators, because measures of distances can be expressed in the same dimension and aggregated. Some progress, however, has also been made in aggregation various aspects of environmental conditions into one index, such as noise, odour and air pollutants (De Boer *et al.*, 1991, see also Hope, Parker and Peake, 1992; Den Butter, 1992).

Up till now, this survey of the literature focuses on national accounting and on the measurement of environmental change and sustainability within the field of descriptive statistics. On the other hand, the theory of economic growth provides the proper framework for a model based analysis of the trade-off between economic activity and environmental change. The discussion in the economic literature about negative effects of economic growth began at the end of the 1960s (see Nentjes and Wiersma, 1992). In the theory of economic growth this discussion resulted primarily in considering the effects of exhaustible resources in models of economic growth. The Report of the Club of Rome and the first oil price shock marked the beginning of this awareness of the problems of exhaustible resources and ecological equilibrium (see Krelle, 1984). Nowadays, the emphasis in models of economic growth has shifted from exhaustible resources to aspects of environmental degradation in a more general sense. Recently, various models of economic growth have been constructed in which the environment plays a prominent role. This development runs parallel to the emergence of the theory of 'endogenous' growth. For such inclusion of the environment in models of endogenous growth we refer to Van der Ploeg and Withagen (1991), and Gradus and Smulders (1993).

In order to illustrate the main characteristics and specification options of a model of economic growth which takes account of environmental change, we present an archetype of such model.[1] The model includes the environment, both in the welfare function and in the production function, and it distinguishes between flows and stocks in the specification of the environment as a factor of production. Assuming that production is homogeneous of the first degree in labour we have the following production function

$$q = f(k, e, s_e), \tag{1}$$

where all variables are expressed in units of labour and where

q: production
k: physical capital
e: environmental capital (= indicator for the state of the environment)
s_e: extractive use of environmental capital

Besides s_e the control variables (instruments) of the model are

i: investments in physical capital
i_e: investments in environmental capital

Total consumption is then defined as

$$c = q - i - i_e. \tag{2}$$

Hence the model considers a closed economy that consumes all production not used for investments.[2] The physical capital stock is built up in the following way:

$$k = k_{-1} + i - \rho k_{-1} \tag{3}$$

with ρ: depreciation rate of capital

The dynamic equation for environmental capital differs from that of physical capital:

$$e = e_{-1} + i_e - s_e + \alpha(e_n - e_{-1}) \tag{4}$$

Here $\alpha(..)$ is a 'regeneration function' which describes the extent of automatic regeneration ('self-regeneration') of the environment in case of extractive use. e_n represents the fully regenerated environment. Obviously $\alpha(..)$ is a non-linear function, which is ecologically determined. Moreover, equation (4) implicitly presumed that investments in environmental capital are equal to the money value of the improvement of the environmental quality that these investments bring about. This presumption is made for the sake of simplicity but can be relaxed by including a function $\beta(i_e)$ instead of i_e in (4) which may, for example, allow for decreasing returns of environmental investments. We note that in their theoretical model of optimal growth with renewable resources Tahvonen and Kuuluvainen (1991) use a specification of the regeneration function which assumes that changes in the stock of the environmental capital affect the growth of biologically regenerating resources.

The solution of our archetypical model results from the welfare optimization:

$$\max \int_0^\infty u(c, e)e^{-rt}\,\mathrm{d}t$$

where u represents the utility function and r is the discount rate of future consumption.

This model makes a number of specification choices explicit which are of immediate relevance for the measurement of the trade-off between economic growth and the state of the environment. For instance, the specification of the utility function represents the valuation problem between the state of the environment and the other target variables in the welfare function (consumption in this case). Clearly we need a more full fledged model of the economy, if the welfare function is to include other traditional goals of macroeconomic policy as well, such as price stability, participation in employment, and the income distribution. Hence, a full assessment of the trade-off between these policy targets is only possible within the framework of an empirical model of the economy.

The theoretical model above also illustrates questions which are directly related to the definition of national income in national accounting. Whereas national product is a flow figure, production uses both stocks (e) and flows (s_e) of the environment. Examples of the use of stocks are all environmental services which are non-extractive and which do not involve commodity flows. We can think of the carrier services of the environment, which supply physical and mental support to productive activities, e.g. by enhancing labour productivity because workers avail of recreational possibilities and of clean air. On the other hand air pollution and other types of environmental stress may cause illness and therefore a decrease of labour productivity. Research and education, which are, in a broad sense, part of the production process, can be hampered by environmental degradation. Climatological change provides another example why the state of the environment is an important factor in the production function.

The flows from environmental capital used in production are sometimes labelled environmental goods (Gilbert, 1994). They include extractive use of non-renewable natural resource stocks (fossil fuels and minerals) and of renewable natural resource stocks (wood, fish, wildlife, suppliers of livestock, crops, impounded water etc.) and are mainly associated with positive commodity flows. The regeneration potential of the environment with respect to the extractive use of these goods differs widely amongst the various types. At the one end of the scale there are completely non-renewable resources for which the regeneration parameter α is identical to zero. The discovery of new sources (addition to known stocks) is implemented in the model by i_e, which in this case represents search costs.[3] At the other end of the scale of the extractive use of environmental goods we have, for instance, noise pollution. When production would stop at the end of the period, in the next period there would be complete silence. Thus, this example has complete and immediate (self-)regeneration so that the regeneration function α is identified as $e_n - e_{-1}$. Here, e_n represents the 'natural' state of silence. A related example regards the pollution of a river. When pollution starts in one period and stops in the next period, the river would again be unpolluted in that period (provided that its source is not polluted). Then again $\alpha \equiv e_n - e_{-1}$. However, when pollution of the river has been prolonged over a long era, the sediments have become polluted so that no full and immediate regeneration can take place and $\alpha < e_n - e_{-1}$. It may even occur that the sediments will never again be as clean as in the 'natural' state. Then it holds that $\alpha\,(e_n - e_{-1}) \leqslant e_n^* - e_{-1}$, where $e_n^* < e_n$.

The use in production of resources which are partly self-regenerating is to be considered as an intermediate case in between the two extremes discussed above. In this respect the model may capture a sepcific feature which is at the core of the discussions on ecologically sustainable development, viz. the existence of a critical load beyond which environmental degradation is irreversible when the environment no longer has self-regenerating power. In that case $\alpha \equiv 0$ whenever $e < e_c$, where e_c represents the critical load.

The so-called 'habitat' use of the environment, when natural areas are utilized for building purposes (housing, plants, roads, harbours etc.), can also be cast in terms of the model. Here we have extractive use of the environmental capital (s_e) in the period of transformation of the natural area, with no self-regeneration ($\alpha \equiv 0$). As a matter of fact investment costs (i_e) are to be made in order to restore the building site to its original shape when it is no longer used for productive services. During the period of use of the building site after the transformation period no further environmental degradation occurs ($s_e = 0$; waste pollution or other externalities excepted) and the productive services of the site enter into the production function through the physical capital stock.

Obviously, an appropriate typology and good technical knowledge of various uses of the environment in production is needed in order to arrive at the proper specification of the production function and regeneration function in this modelling framework. However, such knowledge and the distinction between flow and stock effects of the environment in production is also a prerequisite for inclusion of the environment in national accounting.

3. Welfare and the Environment

The link between optimal economic growth and a national welfare measure in the national accounting framework is illustrated by Mäler (1991) using a model of economic growth similar to the archetypical model of the previous section. This model allows Mäler to define a concept of national welfare consistent with optimal economic growth when environmental resources are taken into account.[4] He concludes that the conventional measure for national product should be adjusted in the following ways:

1. the flow of environmental damage should be deducted from conventional NNP; this regards the households marginal valuation of, for example, the increase in air pollution, where clean air is considered as a flow resource;
2. the value of the net change in the stocks of all assets and not only man-made capital should be added to conventional NNP; hence when due to 'regeneration' the stock of timber or the population of a certain fish increases, the NNP should increase as well; this increase in environmental capital should be valued at a price reflecting the future value of the stock, both as a source of inputs to production and as a direct source of utility to households, and as a source of productivity in production;
3. investments in the enhancement of stocks of natural resources should be treated as intermediary products, and should be deducted from the conventional NNP; an example is the input of fertilizers in forestry or agriculture;
4. existing wealth, as the return on the total stocks of assets in the economy, should be added; it should be valued by the households marginal valuation.

With these adjustments, there is no need to deduct defensive expenditures from NNP (e.g. using goods for extra insulation, cleaning etc.) or to make any other similar adjustment. Although Mäler's analysis is very convincing, the main problem of how to value environmental capital and environmental resources remains. In conventional national accounting production is valued at market prices, but no such market prices exist for the use of environmental services. Within the framework of the optimal growth model prices are taken along the optimal trajectory and all quantities — output, environmental variables etc. — are valued at those optimal prices. Moreover, the list of four major corrections above shows that even along the optimal trajectory the valuation varies with the type of correction.

Although most certainly the economy will in fact deviate from its optimal trajectory, in the context of a growth model valuation at optimal prices seems the natural way of valuation.[5] However, such valuation depends on the specification of the production function and, more specifically, on the specification of the utility function (or welfare function), which contains the weights of the (political) trade-offs between the various targets of economic policy. Here it includes the weight given to environmental quality. Hence, the valuation problem is most prominent when linking environmental welfare aspects to national accounting.

This problem of determining the benefits ("price") of environmental improvement is well recognized and many practical solutions have been put forward (see Hoevenagel and Opschoor, 1991; Shechter, 1991). Broadly speaking, three groups of valuation methods can be identified: dose-response methods, market behaviour methods and survey methods. The first method is based on the fact that environmental quality is a factor of production for many economic activities. For example, industries using water for processing purposes or as ingredient in their products as compared to industries that use water only for cooling. In case of the former use of water, the benefits of environmental improvement (e.g. improved water quality) are inferred from either lower production cost, or from changes in price, perhaps due to a higher quality, and quantity of output. The economic valuation of the environmental improvement, or alternatively of the poor state of the environment, is then indirectly derived from market values. Market behaviour methods are based on the assumption that environmental quality is an argument in people's utility function. In other words, people do have specific environmental preferences. As people are supposed to base their actual market behaviour on such functions, it might be expected that changes in environmental quality are thereby revealed. For example, when buying a house, buyers are assumed to have included in their purchase decision the surrounding air quality and/or traffic noise (the basic idea of the so-called hedonic price method).

Yet another method to discover the value of environmental goods is to survey consumers. A prominent survey method is the so-called 'contingent valuation' method (CV). Briefly, this method attempts to price the environment by creating a hypothetical artificial market in the survey instrument in which respondents are asked to rate their maximum willingness to pay for a carefully described environmental improvement. Given that the sample is representative of the population, the aggregated sum can be conceived as the benefits of the described improvement (for an example, see Hoevenagel and Verbruggen, 1989).

Economic valuation methods should be judged against their practical and technical applicability. The former relates to the range of environmental issues to which they can be applied. The latter relates to the extent to which the methods can derive valid and reliable values and to the value components included, as different types of values can be distinguished. The total economic value of an environmental resource can first be subdivided into use values and non-use values (Pearce and Markandya, 1989). The use values comprise the benefits that are derived from the actual use of a resource. The non-use values refer to a category of rather intangible value concepts that can be derived from the prospects of the use of a resource. Among these concepts is the so-called 'option value', which is essentially a preference for the preservation of an environmental resource against some probability that others will make use of it at a later date. The option value thus consists of vicarious benefits. If future generations are conceived as potential beneficiaries, this value is sometimes referred to as bequest value. Another important component of non-use values is the existence value. People do attach a value to the mere existence of nature and environmental goods, irrespective actual or optional uses. For a great many people (parts of) the environment have an intrinsic value, as is often revealed by the attempts to save endangered species.

In general, the CV method has two strong advantages. On the one hand, its domain of application is large compared to the other valuation methods, on the other hand, this method can measure both use and non-use value. For environmental goods which are unique or have few substitutes, non-use values account for the major part of the measured benefits.

The primary advantage of market behaviour methods is that their resulting benefit estimates are based on actual market behaviour. Consequently, most economists treat these estimates more accurate than those resulting from survey methods. However, methods that rely on data from situations where people make actual market choices must assume that the underlying theory is valid in order to generate results. Moreover, few markets with full information exist for environmental goods: the major problem for the valuation of environmental damage is that of missing markets. On the other hand, survey methods can, in principle, be applied to every aspect of the environment and carry with them the advantage that specific validity checks can be included.

In recent years, the CV method has become the major technique for assessing the value of environmental goods. In the United States, the method is incorporated in the regulations of the Department of Interior for measuring environmental damages due to oil spills, such as the Exxon Valdez spill in Prince William Sound, and hazardous wastes. According to Hoevenagel

(1994) this use demands an unattainable accuracy of the method's estimates. Indeed, the CV method asks respondents to make a highly unfamiliar (budget) decision. Instead of asking whether or not they agree with some political statement, they must provide precise responses to specific questions. Since most people have never stated a monetary value for environmental goods directly, it is quite unlikely they possess well-formed preferences for the issues at stake. It usually remains unclear which (part of) an environmental good is valued, and which value component actually has been honoured. More likely is that they derive their maximum willingness to pay from some basic values and make estimates by using value cues implied by the survey instrument. What we argue is that despite its strong advantages, the CV method has a tendency to result in (upward) biased estimates (see Hoevenagel, 1994). Recognizing that much progress has been made in developing accurate valuation methods, it is premature to conclude that the valuation issue has been settled and that environmental goods can be routinely priced. Moreover, valuation problems in national accounting are of a different order of magnitude than the actual measurement of the costs of environmental damage reported above which relates mainly to the micro level.

4. An Assessment of Hueting's Method

Recently Hueting proposed a practical methodology for the calculation of an environmental correction of national income, which is based on sustainability standards (see Hueting, Bos and De Boer, 1992). The aim of this exercise is to devise

> a criterium for the loss of environment and natural resources in terms of money that is comparable with the indicator of production, national income. The number indicates in money terms how far in a given year society is removed from the sustainable use of the environment that it desires. The difference between the standard national income and the indicator to be calculated shows a sustainable level of activities: the sustainable national income.

The methodology purports to provide policy makers with *one* measure of environmental loss, which can be used alongside environmental indicators cast in physical terms. The major innovation of Hueting's methodology is that he 'solves' the valuation problem by using technical standards *for sustainable use of the environment* as a yardstick instead of the stretchy concept of sustainable development. The environmental degradation is valued at the yearly costs which are necessary to enhance the availability of environmental functions — Hueting's terminology for services from environmental capital — to their standards for sustainable use. The practical valuation problem of this methodology boils down to the translation of these costs in physical units into costs in monetary units. These monetary costs correspond to the minimum costs that must be incurred to bridge the distance between the present situation and sustainable use of the environment. Comparison of this amount with the standard national income yields the sustainable national income.

These costs comprise four categories of measures:

1. costs of technical measures and their introduction;
2. costs of developing alternatives for depletable natural resources, such as replacement of fossil fuels by forms of energy derived from the sun and of copper wire by glass fibre;
3. costs of the direct shift from environmentally burdening to environmentally friendly activities when technical measures are not enough to reach the point of sustainability;
4. costs of reduction of the population and the resultant drop in volume of the activities when categories 1 to 3 lead to an unacceptably low level of facilities per person.

In Hueting's reasoning, the official pursuit of sustainable development by governments can be conceived as a societal expression of preference for the sustainable use of the environment. Sustainable use is then defined as the preservation of environmental functions for future generations. The availability of these functions is dependent on biological and physio-chemical processes. Upsetting the balances among these processes by human interventions threaten these functions. Hence, sustainable use can be attained by restraining these interventions through the imposition of standards. The cost to comply with the standards may comprise one or more of the above-listed categories.

By way of illustration, take the case of acidification. For a sustainable fulfilment of functions it is necessary to limit the deposition of acidifying substances up to the assimilative capacity of specific soil and waters. Critical loads, that are allowed to vary to take account of different soil and water types, can be formulated. In turn, these critical loads can be translated into emission standards with the help of air transport models for acidifying substances. Finally, the cost involved in maintaining these standards can be estimated and constitute the environmental correction of national income.

Against the background of the framework discussed in the previous sections, this specific correction of national income for environmental damage poses a number of questions. Our first concern is with the concept of sustainable use which constitutes the key to Hueting's calculation of the costs associated with stocks and flows of environmental degradation. One could define sustainable use in a narrow sense, namely as the condition that the extractive use of environmental goods is exactly equal to the amount of self-regeneration:

$$s_e = \alpha(e_n - e_{-1}).$$

Under this condition the non-extractive use of the environment and the extractive use with immediate self-regeneration would involve no costs. When the above condition does not hold, and the extractive use of environmental good exceeds self-regeneration, the resulting environmental degradation follows from

$$s_e - \alpha(e_n - e_{-1}).$$

This definition yields an operational method to determine the extent of environmental degradation indeed, but it does not solve the major valuation problems. First, we have seen that the specification of the regeneration function $\alpha(..)$ may differ for each type of environmental good and can be difficult to be determined in practice. A similar argument holds for the 'natural' level e_n. Moreover, this narrow definition of sustainable use does not comply with the costs associated with the non-extractive use of the environment.

Under the presumption of our simple model that investments in environmental capital are equal to the resulting money value of the improvement of environmental quality, sustainable use costs can be defined as those costs (i_e) which keep the environmental capital at the same level e. This is illustrated by the fact that, according to equation (4) of our growth model, the condition

$$i_e = s_e - \alpha(e_n - e_{-1})$$

implies that the level of environmental capital remains constant:

$$e = e_{-1}.$$

Obviously, this condition corresponds to a steady growth in the economy, provided that abatement costs (i_e) do not exceed total production. However, this growth surmises a *status quo* for the amount of environmental capital, whereas the concept of sustainability pertains to a normative level of environmental capital. We acknowledge that Hueting clearly distinguishes this concept of sustainable use from the more general concept of sustainable development and considers it a second best approach. Yet, from the description of Hueting's methodology we infer that it also purports to relate the actual state of the environment to a different state of the environment which complies with the sustainability standards (like sustainability indicators do). In that case, the above condition for sustainable use is too narrow and we should consider a transition from the actual state of the environment (e) to a desired state (e_d). Such transition takes time and the costs associated with it should be spread over a number of years. It is unclear how this time horizon and the appropriate discounting is determined in Hueting's method.

Although Hueting's method assumes that for each aspect of the environment technicians are able to indicate sustainability standards and to calculate the costs associated with complying with these standards, we still face the problem of determining the desired state of the environment. This problem is obviously related to the definition of sustainable economic development, in spite of the distinction made by Hueting between sustainable use and sustainable development. However, after the concept of sustainable economic development has been introduced in environmental economics, a large number of alternative operational definitions for this concept have been given. These definitions yield an equal number of different sustainability standards for the state of the environment. For example Mäler (1991) defines sustainable economic development as optimal economic growth within the context of his model. In the same vein, the desired level of environmental capital can be derived from the welfare optimization in our archetypical model as the level e_d which corresponds to the optimal growth path. Pearce *et al.* (1989) even cite 30 examples of different definitions of sustainable development. Nicolaisen, Dean and Hoeller (1991) arrive at a condition for sustainable development according to which sustainability requires that the real value of environmental depletion must not exceed the real value of net investment in man made capital. Hence, there is no unanimity amongst economists about a proper definition of sustainable economic growth and hence about the state of the environment, which is desired from that perspective; neither will there be with environmentalists or technicians about sustainable use of the environment.

Therefore, we still face the problem of the valuation of environmental change. As our survey of the previous section shows many valuation methods exist and calculation of the cost of repair of environmental damage is only one of these methods. The main objection against this method is that the costs of repair are not necessarily equal to the welfare losses associated with that environmental damage.[6] Moreover, sustainable economic development (or sustainable use) relates to a hypothetical reference scenario in which production prices may deviate substantially from actual production prices. The conventional measure of national income in the reference scenario cannot be, for that reason, equal to that of actual income. It implies that a measure of sustainable national income does not only differ from the conventional figure of national income of the national accounts because it includes a correction for environmental damage, but also because national income itself has changed in this hypothetical situation.

Another major problem with Hueting's correction method in particular, and calculation of a green GNP or eco-GNP in general, concerns the use of income as a measure of welfare. Following Nyborg (1991) one can think of three reasons for such a correction:

1. one wishes to correct net domestic product for environmental degradation to improve national product as a welfare measure;
2. one wishes to establish to what degree current economic activity could

have prevailed if the environmental standard were not allowed to deteriorate;
3. one wishes to correct national product for the costs of restoring factual deterioration of the environment in the accounting period.

These three different points of view imply different corrections of national product because each alternative requires its own manner of valuation of environmental change. For instance, when actions to prevent damages are cheaper than actions to repair damages the corrections with respect to goals 2 and 3 will differ. Since environmental goods, in many cases, cannot be produced by humans, restoration costs can, in fact, be infinite, whereas avoidance costs will in no case be greater than value added, as damages could have been avoided by closing down production. Hence, there is no reason to believe that 2 and 3 can be regarded as approximations to each other. Hueting's proposal seems to accord with goal 3, although, as mentioned before, he does not confine the calculation of the restoration costs to the accounting period. Yet, Nyborg convincingly demonstrates that the methodology for calculating the correction may vary with the purpose of the correction.

Moreover, we may consider the more principal question why we should correct national income anyhow. The present calculation of national income, following the national accounting guidelines, is based on (the value of) market transactions: if we would like to include externalities due to market failures into our definition of income, national income should be corrected for all (positive and negative) externalities and not solely for environmental change. The argument that a correction for environmental change improves national income as a measure of welfare is ambiguous as well. There are many other quantifiable aspects of economic welfare: why correct national income for environmental quality but not for a skew income distribution or high illiteracy? Incidentally, human development indicators or quality of life indicators provide such composite measures of national welfare.

5. Evaluation

This article surveys problems associated with the measurement of environmental change in national accounting. It considers two different procedures for statistical registration of data which are designed to reveal the mutual relationship between economic and environmental factors. The first procedure is a direct correction of GNP (or NNP) for environmental change which yields an 'environmentally adjusted' GNP (NNP). We amply discussed the method proposed by Hueting in this respect. The second procedure purports the construction of satellite accounts containing information on environmental factors. This information in satellite accounts relates to physical indicators, which can be juxtaposed to the conventional welfare indicators in a social welfare function. In that case, shadow prices for environmental capital can be deducted from welfare optimization (see Mastenbroek and Nijkamp, 1976 for an early attempt) so that the monetising of environmental change is left to the users of the satellite accounts. On the other hand, calculation of an adjusted GNP implies an immediate monetising of environmental change, based on an implicit model.

Two major problems are connected with the construction of economic data on the environment:

— the kind of analysis for which the data are used;
— the valuation of environmental change.

A major empirical use of such data is measurement and analysis of the trade-off between economic growth and environmental quality. However, we have argued that this use of the data has no clear and unequivocal implications for the procedure of data construction.

This is due to the second problem, namely that of environmental valuation. The valuation problem has a *technical* and a *judgemental* dimension. Within the theoretical framework of a model of macroeconomic growth these dimensions are readily separable. In the archetypical growth model presented in Section 2, the technical problem comprises the specification of the production function, the aggregation of various types of environmental capital (which we have altogether left out of consideration in our discussion of the model) and the specification of the regeneration function (including determination of the 'natural' level of the environment). The judgemental problem relates to the specification of the utility function (weights attached to environmental quality in relation to other macroeconomic policy goals), the choice of the discount rate (measure of time preference and altruism with respect to future generations) and the selection of the sustainable or 'desired' level of environmental capital. The latter is implicitly determined by optimal growth, when the specification of all required functions and all data have been established. In that case, calculation of shadow prices of optimal growth solves the valuation problem.

However, practice does not allow such clear separation of the technical and the judgemental dimensions of the valuation problem. This is our main criticism of Hueting's argument that his definition of sustainable use would solve the valuation problem by making it a sheer technical one. We believe that his method, and for that reason each calculation method of an environmentally adjusted GNP, still implicitly contains judgemental choices which are political and not technical choices. We realize that the aggregation of environmental indicators to one or a limited number of general indicators on environmental quality also involves an element of judgement in case these various aspects of environmental quality enter into the utility function separately. However, in case of separability in the utility function it becomes a two step problem. In the first step the various aspects of environmental quality are valued amongst each other, and in the second step the value of environmental quality is judged against the other aspects of economic welfare.[7] This judgemental valuation of the second step should not be made by statistical agencies without an extensive sensitivity analysis.

Table I summarizes our arguments with respect to the use of physical indicators of environmental quality versus GNP (or NNP-) corrections in economic analysis.

Table I. Assessment of calculation of environmental quality indicators versus GNP correction

Physical indicator(s) of environmental quality

- it leaves the judgement on the trade-off between environmental quality and economic growth to the user
- the valuation problem is restricted to the construction of basic indicators for the various aspects of environmental quality and to the aggregation of these basic indicators into composite indicators; the construction method of these composite indicators makes this valuation problem explicit
- the user determines how the data are to be used
- there is no *a priori* concept for monetising environmental quality
- there is no implicit definition of sustainability when using these indicators

GNP-correction

- it contains an implicit judgement on the trade-off between environmental quality and economic growth
- the valuation problem involves monetising of environmental quality consistent with national accounting
- the correction method may depend on the purpose of the correction
- a correction consistent with the theory of economic welfare is only feasible in the context of a model of optimal economic growth
- the calculation of the costs of repair associated with sustainable use of the environment is useful, but should not be regarded as a correction on GNP

In spite of our criticism on GNP-corrections made by official statisticians we advocate that national accounting should proceed along both lines indicated above: construction of satellite accounts (and derivation of environmental indicators) and an estimation of the money value of environmental degradation (or upgrading) in relationship with national production. The official statisticians should try, as much as possible, to harmonise both methods as they are partly complementary. Moreover, it is of great importance that the environmental economists speak with one voice: environmental decay has become too serious a problem to allow that vital policy recommendations made to improve the state of the environment are enervated by public dispute between specialists.

Against this background we emphasize the valuation problem: economists should not provide a policy diagnose with an implicit political valuation. For that reason, when environmental adjustments of GNP or NNP are made public, the valuation should be made explicit in a sensitivity analysis of the major assumptions of the adjustment method. Moreover, statistical data should not contain an implicit assessment of the trade-off between a clean environment and economic growth; only a model based approach enables such assessment. This article indicates that in that case the trade-off depends on the specification and the parameter values of the (growth) model.

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Notes

[1] Nijkamp and Paelinck (1973) already considered optimal growth in a similar dynamic model including environmental capital.

[2] The open economy assumption will, of course, complicate the model, but does not change the essence of our arguments.

[3] On the proviso of rational search with full information so that search costs are set equal to expected gains from new sources.

[4] Solution of the optimal growth path of our model would imply similar rules for calculating national welfare in the national accounting framework. Apart from technical difficulties we have not tried to find such solutions because our model is merely to illustrate the distinction between the technical and the judgemental aspects of the problem. For an extension and critical inspection of this approach to national income accounting we refer to Vellinga and Withagen (1993).

[5] As a matter of fact, according to Mälers' analysis wages in the production of goods should also be deducted from conventional NNP, as on the optimal trajectory the labour market is in equilibrium so that the wages are equal to their opportunity costs, i.e. the vacation time that must be given up. Thus, on the margin an increase in labour supply does not increase welfare.

[6] Apart from this, it should be realized that the costs of repair are a function of the state of technological development, and hence, are time dependent. If as a result of technological development or economies of scale cheaper repair technologies come available, the full time series of corrected GNP figures will increase. For a number of other arguments refuting the cost of repair approach (or similarly the 'avoidance cost' approach) we refer to Keuning (1992).

[7] The first step in this valuation can, in fact, again be decomposed into two interrelated stages, namely the construction of basic indicators from physical quantities, and the aggregation of these basic indicators.

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